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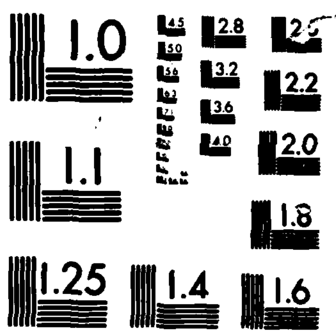

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A PORTABLE SUBJECT CONTROLLED NIGHT VISION ADAPTOMETER

U S ARMY RESEARCH INSTITUTE
OF
ENVIRONMENTAL MEDICINE
Natick, Massachusetts

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This report describes a new adaptometer which was designed at this Institute for assessing night vision parameters of the military population at field sites, and to quantify the effects of extended exposure to high altitude. The instrument is based on a previously developed concept of dark adaptation measurement in which the subject continually adjusts the threshold luminance of a recurrently flashing stimulus. This device, however, represents a modernized version of the technique which employs computerized data translation.

It also offers the advantages of rugged construction and field portability. The instrument has functioned reliably in field conditions, and has generated valid dark adaptation functions on soldier test subjects in use at the USARIEM High Altitude Test Facility, Pikes Peak, Colorado. Keywords:

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2. Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

A Portable Subject Controlled Night Vision Adaptometer

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FOREWORD

The concept of operation and measurement approach involved in the instrument described in this report were conceived by Dr. John L. Kobrick, Health & Performance Division, as a modification of titration measurement techniques embodied in an earlier adaptometer designed by Dr. Hans Rudolph. The same procedure of successive threshold adjustment is implemented in the auditory testing techniques of Dr. Georg von Bekesy, although the instrumentation and hardware involved are different in each case. The actual device development was accomplished by Mr. Jose Miletti, Instrumentation Branch, and by SP6 Calvin Witt, Health & Performance Division.

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ABSTRACT

This report describes a new adaptometer which was designed at this Institute for assessing night vision parameters of the military population at field sites, and to quantify the effects of extended exposure to high altitude. The instrument is based on a previously developed concept of dark adaptation measurement in which the subject continuously adjusts the threshold luminance of a recurrently flashing stimulus. This device, however, represents a modernized version of the technique which employs computerized data translation. It also offers the advantages of rugged construction and field portability. The instrument has functioned reliably in field conditions, and has generated valid dark adaptation functions on soldier test subjects in use at the USARIEM High Altitude Test Facility, Pikes Peak, Colorado.

INTRODUCTION

The instrument described here was designed for two purposes: (1) to collect a data base of night vision parameters for selected segments of the US Army military population at both garrison and field locations; and, (2) to assess the effects of sustained hypoxia on night vision thresholds as reflected by the human dark adaptation function. Both of these objectives required a night vision testing device which was rugged, reliable and simple to operate. Achieving the prolonged exposures to moderately severe hypoxia which were of interest (16 days) required that the measurements be obtained at a field laboratory maintained by the US Army Research Institute of Environmental Medicine on the summit of Pikes Peak, CO (4300 m elevation). Because of its isolated location, this facility can offer only limited space for testing; moreover, when in use the space is usually occupied by a number of test activities which are being conducted concurrently. Therefore, it was essential that all of the equipment be as compact and portable as possible. In addition, night vision testing could be performed only if the subject and testing equipment could be isolated from the surrounding environment.

The adaptometer which was developed for use in this specialized situation is uniquely self-contained, and can be operated within a normally illuminated room independent of ongoing activities. Unlike currently available clinical adaptometers which characteristically tend to be cumbersome and rather fragile, this system is designed for sturdiness and compactness. Also, it can easily be broken down, shipped and re-assembled in a few minutes. This system has the additional advantage of being virtually automatic, since the test procedure follows a fixed sequence, and utilizes a test stimulus which is directly and continuously controlled by the subject.

The basic measurement technique is a modification of an adaptometer concept originally developed by Hans Rudolph, in which a recurrently flashing stimulus light of variable intensity is continuously adjusted by the subject to approximate his own luminance detection threshold. (Another adaptometer based on this concept, but of an otherwise different design, is manufactured on special order by the Marietta Apparatus Company, Marietta, OH.) In the present instrument, the derived threshold luminance data expressed in log foot-lamberts are plotted versus an advancing time base to provide a conventional dark adaptation function.

DESCRIPTION OF THE APPARATUS

A schematic diagram of the functional system is shown in Figure 1.

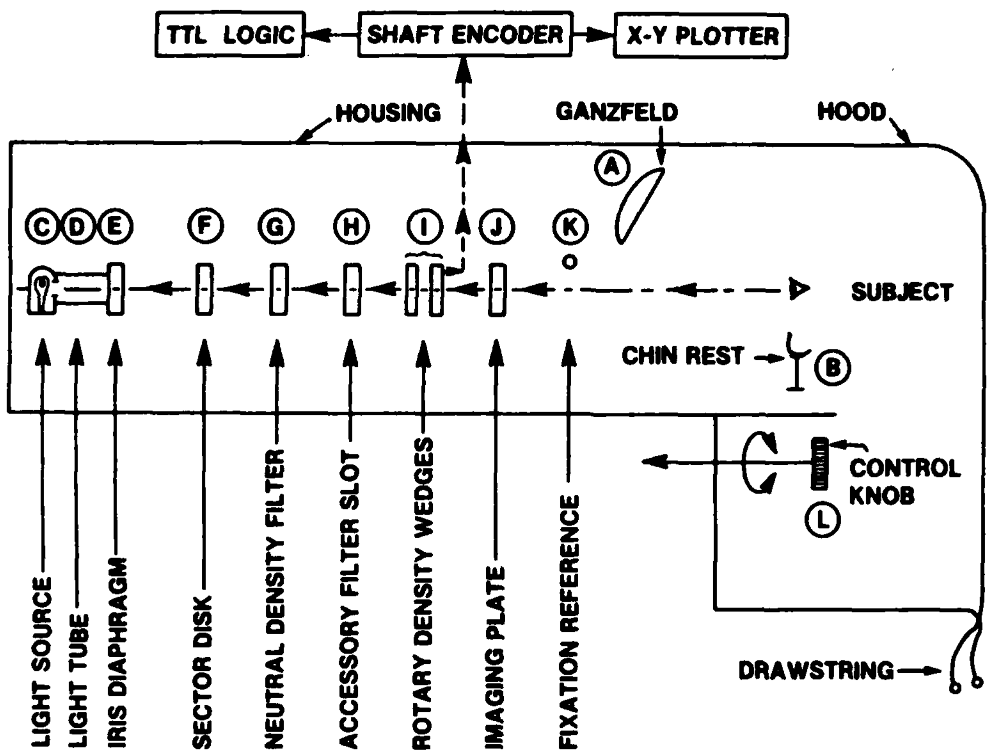

Figure 1. Schematic diagram of the functional apparatus

The entire testing instrumentation is enclosed within a portable rigid light-tight housing. The housing is hinged along the mid-line of the top and bottom surfaces to allow it to be collapsed into a flat compact package for shipping. When the instrument is in use, a fabric hood is attached to one end of the erected housing so as to enclose the subject along with the test instrumentation within a light-tight envelope. The subject enters the hood through an opening at its bottom, and a drawstring installed in the edge seam of the opening is tightened snugly around his waist. This enclosure design provides a comfortable and totally dark testing environment which is independent of the external ambient illumination. A small light-proof silent electric ventilation fan is mounted within the housing, and provides both an air supply to the subject and a means of dispelling heat. It should be noted

that when the instrument was used at high altitude, the ventilation fan also served to insure that the prevailing hypoxic atmosphere was accurately duplicated inside the testing enclosure.

A hemispheric surface painted flat white (Ganzfeld) (A) is positioned overhead and frontal to the subject's view in the seated position. This surface is illuminated indirectly by a 60-watt tungsten filament incandescent bulb mounted at its lower edge in a shielded receptacle. This device is used to pre-adapt the subject to a photopic threshold level prior to testing. When seated comfortably, the subject leans slightly back and orients his gaze upward at the illuminated Ganzfeld for approximately five minutes. Thereupon, the Ganzfeld is extinguished, and the subject leans slightly forward into a chin-head rest (B), which is mounted at one end of a 36-inch optical bench so that the line of sight falls along its longitudinal axis.

The test stimulus is generated by a 40-watt incandescent tungsten filament light source contained in a lamp housing mounted at the other end of the optical bench. The housing contains a 1-inch circular aperture fitted with a milk-glass diffuser (C), with the aperture facing the subject. A scatter-eliminating light tube with a flat black inside surface (D) joins the light source aperture to a variable-aperture iris diaphragm (E) used to establish the size of the stimulus. The resulting stimulus then is intercepted by a sector disk rotating at 15 rpm, and containing a 22.5 degree angular gap (F). This arrangement produces a flash stimulus of 0.25 second duration occurring at a rate of 15 flashes per minute (one flash every four seconds), which is sufficiently intermittent and brief to have no effect on the natural course of the dark adaptation process. The stimulus is imaged then along the optic axis in sequence through: a Wratten neutral density filter stage used to adjust the range of the stimulus luminance (G); an accessory filter stage to allow insertion of chromatic filters when desired (H); a pair of circular counter-rotating matched neutral density wedges (Kodak No.96) mounted in a Gerbrands gear-drive optical wedge holder (Model G1310) (I); and, a 2" x 2" fused-glass diffusion plate (J) for imaging the emergent visual stimulus. A 1/8" circular red light (K) is mounted on a horizontal slide-wire placed perpendicular to the optic axis and 1" above the imaged stimulus. This light assists the subject in maintaining fixation of the stimulus without altering the dark adaptation threshold. It can be adjusted easily for desired obliquity to the stimulus by moving it along the slide-wire to the desired position.

The gear drive of the wedge holder is directly connected by a straight shaft to a control knob (3 inches diameter) mounted convenient to the subject's right hand position (L). A clockwise rotation of the control knob decreases the luminance of the test stimulus by increasing the density of the wedges; conversely, a counter-clockwise rotation increases the stimulus luminance.

This overall arrangement produces a recurring intermittent flash stimulus which the subject can continue to increase or diminish in luminance by appropriate manipulation of the control knob to approximate the momentary luminance level of his dark adaptation threshold.

An optical incremental shaft encoder system with zero reference option (BEI Electronics; Model 260: 1000 counts per turn) is coupled by direct

gearing to the output shaft of the wedge holder to provide digital quantitative encoding of the equivalent optical density of the wedges throughout their 360-degree rotation. The encoder interfaces through a voltage dividing circuit with the input terminals for the ordinate (Y) axis of an analog X-Y graphic recorder (0-20 volts DC, maximum excursion; Hewlett-Packard Model 7004B, or equal). The Y-axis of the recorder was calibrated empirically to represent the occlusion range of the optical wedges. This was done by measuring the virtual luminance of the visual stimulus at a variety of settings of the variable density wedges throughout their absolute rotation using a digital photometer (e.g., Spectra Model U1-B, with night filter option), and marking the associated positions assumed by the cursor of the recorder along its Y-axis to provide a scale of equivalent stimulus luminance in units of millilamberts (mL). The abscissa (X) axis of the recorder is driven by a plug-in time base module advancing the cursor pen at a constant rate of 0.57 inches per second, which spans approximately a 12-inch baseline sweep over the conventional 20-minute night vision testing period.

The shaft encoder system also outputs to a dial-reading display to provide additional direct verification of the optical wedge positions at all times, and also generates associated TTL-compatible logic for computer conversion of the derived dark adaption threshold functions.

In summary, the system described above generates a target stimulus flashing at a constant rate of occurrence, which the subject continues to adjust to the lowest detectable (threshold) value over the course of the test period (usually 20 minutes). The X-Y recorder plots the equivalent luminance values in millilambert units represented on the Y-axis of a graphic recorder, versus the continuously advancing time base plotted on the X-axis, resulting in a graphic representation of the conventional dark adaption function.

Complete construction plans, optics and wiring diagrams can be obtained by contacting the authors at the above address.

SUGGESTED SOURCES OF COMPONENT EQUIPMENT

Ealing Corporation, 22 Pleasant St., South Natick, MA 01760; Tel. (617) 655-7000 (Lamp housing; iris diaphragm; filter stages; optical bench)

BEI Electronics, Inc., 1101 McAlmont St., Little Rock, AK 72203; Tel. (501) 372-7351 (Optical shaft encoder with zero offset; and associated digital readout. These components are recommended as replacements for an integrated shaft encoder system formerly manufactured by Astrosystems, Inc., Cambridge, MA, no longer in business.)

Hewlett-Packard Co., Inc., Consult regional offices (X-Y graphic recorder).

Ralph Gerbrands Company, 8 Beck Road, Arlington, MA 02174; Tel. (617) 648-6415 (Optical wedge holder)

Eastman Kodak Company, Rochester, NY, Consult local Kodak dealers (Rotary optical wedges)

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